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ORIGINAL ARTICLE

Evaluating the impact of energy interventions: home audits vs. community events

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Abstract New Zealand's housing stock tends to be of low thermal quality that can adversely affect the health and well-being of occupants as well as costing more than necessary to heat. Householders need information and motivation to make material changes and adopt new practices to achieve warmer and more energy-efficient homes. This study compares two different types of energy interventions with householders in three different suburbs in Dunedin, New Zealand. Two suburbs received a home energy audit whereby an auditor surveyed each house and provided personalised advice. Householders in the third suburb took part in community energy events that included general advice and practical workshops. The impacts of these interventions were evaluated through pre- and post-intervention surveys and post-intervention interviews. Home energy audits were successful in encouraging change both behavioural and practical, where it was possible. The energy events promoted community engagement and awareness relating to energy-saving actions. Participant feedback suggests that a combination of both types of intervention may be most effective in promoting household change, beginning with energy events in communities before offering home energy audits. This would enable people to share their thoughts and concerns about energy with the support of their social networks and engender trust in the process, before offering personalised audits. Overall, the results show that interventions need to be correctly targeted to appropriate communities to be effective.

Keywords Energy · Housing · Intervention · Home energy audit · Community events · Behaviour change

Introduction

Much of New Zealand's housing stock is of low thermal quality, which can adversely affect the health and well-being of occupants, as well as costing more than is necessary to heat. Improving the efficiency of energy use within homes can assist with all of these problems, but the efficiency journey can be complex and expensive, and householders often need support to make appropriate changes that suit their homes and their personal circumstances. The research reported here contributes to the literature on ways to design and present household energy interventions to different communities under different circumstances.

The imperatives for improved energy efficiency in New Zealand homes are somewhat different to those in

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many other developed nations. Within European Union countries, for example, EU directives for improving household energy efficiency are largely driven by carbon reduction targets (European Council 2014; European Commission 2013). In New Zealand, an unusually large proportion of residential energy consumption is derived from low-carbon sources: electricity comprises 69 % of all energy used; solid fuels (mainly wood) provide another 20 %, and there is relatively little use of gas (Isaacs et al. 2010). Furthermore, around three quarters of electricity in New Zealand is generated from renewable resources (Ministry of Business, Innovation and Employment 2013). As a result, while NZ households certainly do contribute to greenhouse gas emissions (Romanos et al. 2014), their share from energy use is far less than in countries that rely more heavily on coal and gas as direct or indirect energy sources.

Another difference is that household energy use per capita is already very low. Research based on 1995 data revealed that, on a climate-corrected basis, New Zealand had the lowest residential sector energy use per capita than a number of OECD countries with similar living standards (Schipper et al. 2000). This variance appears to have continued, with per capita household energy use today being around half of that of Ireland, Germany, France and the UK (International Energy Agency 2013). The reasons for this lower consumption have not yet been fully explored, but New Zealand homes are certainly cooler than those in many OECD countries. The National Household Energy End-Use study showed that national average winter living room temperatures during 2001–2006 were under 18 °C and bedroom temperatures under 14 °C and also that mean daily living room temperatures over winter months were around 16 °C. Most households only heated their living rooms, and bedrooms were heated overnight by only 16 % of households (Isaacs et al. 2006, 2010, Lloyd et al. 2008).

Even where heating is applied, much of the housing in New Zealand has poor thermal performance, leading to major heat losses. A history of relatively weak housing regulation has resulted in a significant proportion of housing stock being either poorly insulated or not insulated at all (Public Health Advisory Committee 2002), and there is no requirement for rental properties to provide either insulation or heating (Howden-Chapman et al. 2012). A study by the Public Health Advisory Committee found that one third of the 900,000 homes built in New Zealand prior to 1978 are either inadequately heated or not heated at all (Public Health Advisory Committee 2002). Homes in New Zealand tend to be heated with either fixed (e.g. open fire) or portable heating appliances with only 5 % of households having central heating. Older houses and South Island homes (71 %) are more likely to have solid-fuel heating appliances (Isaacs et al. 2010). Substandard housing, and in particular that which is cold, damp and mouldy, has been found to play a role in the development of asthma and other respiratory health problems (Dunn et al. 2004; Howden-Chapman 2004; Breysse et al. 2004; Toi Te Ora - Public Health Service 2009). New Zealand's neoliberal regime means that governments generally eschew subsidies, but the clear link between poor housing and ill-health was sufficiently convincing that a subsidy for underfloor and ceiling insulation was introduced in the 2000s and has resulted in around 230,000 homes being insulated (Energy Efficiency and Conservation Authority 2014).

Yet, even if householders manage to insulate their homes, this alone has been shown to have a minimal (average 0.4 °C) impact on indoor temperatures (Lloyd et al. 2008). More heating or more efficient heating systems are required to achieve a warmer indoor climate, but many householders are in relatively straitened circumstances. An estimated 17.2 % of households nationally are already spending more than 10 % of their household income on energy (Lawson et al. 2015). Low-income households are unlikely to be able to make significant investments to improve the physical qualities of the home, and this is even more unlikely if they are in rental properties.

The policy drivers for more efficient energy use in NZ households are therefore not as focused on reducing overconsumption and carbon emissions and are much more about health, improved comfort and controlling costs. Rather than needing to curb their use of household energy, it is apparent that many New Zealanders may not be using enough energy (or not using it efficiently enough) to achieve comfort and health, which is exacerbated by poor building quality. Improving energy efficiency can help householders address all of these factors, but efficiency is a journey that is rarely straightforward due to the variability in housing stock, appliances and lifestyles. Interventions, such as information, advice and support, can inspire and enable householders to take action towards greater energy efficiency.

Literature review

There are a number of different types of interventions that can be used to promote residential energy efficiency. Antecedent strategies include approaches such as providing information, encouraging energy commitments and goal setting. These aim to influence the determinants of energy-related behaviours prior to an action being taken. On the other hand, consequence strategies, such as energy feedback and rewards, aim to influence behaviour after the occurrence of that behaviour (Abrahamse et al. 2005). In the New Zealand context, strategies such as energy feedback and goal setting, which tend to encourage households to reduce consumption, might not be appropriate because achieving greater comfort and health may involve the use of more energy or at least using the same amount of energy more effectively.

Energy efficiency actions are typically segmented into two categories of behaviour: efficiency and curtailment (Gardner & Stern 2002). Efficiency behaviours usually involve material changes and entail the acquisition and installation of energy-efficient equipment, such as insulation, double glazing or efficient appliances. Curtailment behaviours involve repetitive efforts to reduce energy use, such as turning off lights, drawing curtains or drying laundry outside (Abrahamse et al. 2005). However, use of these categories to define the parameters of energy behaviour tends to place them in isolation and fails to account for the social context within which behaviour occurs.

The importance of social and cultural influences on mediating energy behaviour has long been recognised. In an early effort to encourage energy efficiency in the USA in 1978, the Residential Conservation Service (RCS) instructed utilities to provide their customers with free home energy audits. This led to energy efficiency changes by less than 3 % of the households and average energy use per household fell by only 2–3 % (Hirst et al. 1981). The low participation rates and low energy reduction were explained by a US National Research Council report which stated that the RCS overlooked 'the rich mixture of cultural practices, social interactions, and human feelings that influence the behavior of individuals, social groups and institutions' (Stern et al. 1984). More recent studies reinforce that energy-related behaviours including the adoption of new technologies can be strongly influenced by social networks, and thus, people may be more influenced by norms than information and advice from outside of their networks (Bartiaux 2008; Gram-Hanssen 2011; Strengers 2011). Tapping into these social networks to encourage a broader interest and engagement in energy efficiency changes may result in more effective interventions. Understanding the target population is also crucial: recruitment into energy efficiency programmes has been found to be dependent on community infrastructure, and highly motivated individuals within the community can be utilised to motivate others who would tend to have minimal participation (Strohm 2011).

In order to know what energy efficiency improvements are more appropriate for their homes, households also require access to transparent, objective, trustworthy and personalised information (e.g. Fischer 2008; Darby 2001). Facilitating informal and experiential learning in a social context can strongly support energy awareness and actions (Darby 2006a, b). Home energy audits can provide more personalised information; these comprise an inspection of a property to evaluate its energy use and efficiency. Recommendations are then given to the householders about opportunities for improving energy efficiency or comfort. A wide range of tests can be employed within an audit, and these can vary depending on the auditor.

However, a criticism of audits is that providing information is not enough: the characteristics of the target population, trust, language, ease, incentives and persistence are all important to a program's success (Fuller et al. 2011). If householders do not understand the information provided by an audit, the audit process can fail to generate change (Palmer et al. 2013). More generalised knowledge and awareness about energy (such as how to understand an energy bill, how much energy is consumed by different devices, how thermal loss occurs and the relative impact of different efficiency actions) are also crucial in helping householders decide to take action, and if so, what action to take (Palmer et al. 2013; Brounen et al. 2013; Harries et al. 2013; Whitmarsh et al. 2011).

Householder action on efficiency thus appears more likely where (a) they have a basic knowledge about energy in the home, (b) they have information crafted to their own circumstances and (c) their aspirations to change are supported by their social networks. In practice, individual home energy audits can provide (a) and (b) but not (c). Community-based energy events, which tap into existing social networks and bring people together to learn and share, can provide (a) and (c) but not

(b). Community-based interventions are not able to provide energy advice personalised to the same level as that which can be provided during a one-on-one audit within a home but may be more effective in bringing to play the power of social networks and experiential learning. Our research set out to test which of these combinations was most effective in bringing about change: highly personalised energy audits and less personalised community-based energy events,[1] which instead offered the opportunity to tap into existing social networks and communication structures. In addition, we wanted to assess whether there was a difference in the sort of actions that are promoted or adopted in these two different approaches and whether the provision of personalised and tailored advice was more effective when there is already a strong community-wide engagement with energy.

In the energy field, there has been an increasing interest in looking beyond individual decision-making processes to the social and structural context within which decisions are made (Bartiaux et al. 2014; Hargreaves et al. 2013; Shove 2004). The concept of 'energy cultures' (Stephenson et al. 2010, 2015) is particularly helpful in this respect, in offering a framework for considering the way in which a household's patterns of energy use are shaped by a combination of external factors over which they have little or no control and also by the everyday interactions between norms, practices and material culture (the technologies and physical infrastructure of the home) (Fig. 1). Norms comprise how people expect or desire to live their lives and are strongly mediated by both personal circumstances and the social norms exhibited by their social networks. Expectations may differ from aspirations: New Zealand householders may well have expectations that their living room will average 16 °C in winter but may aspire to 20 °C. Material culture comprises both the physical structure of the house and the appliances and technologies relating to energy use in the home, such as type of heating method. Practices refer to the energy-related actions and activities that people perform in their home, such as closing curtains or turning up the thermostat. A person's or a household's energy culture is the outcome of interactions between these influences.

[1] Community-based energy events can take many forms. In this paper, the term refers to workshops and energy efficiency events that are organised within a community for the benefit of the participants.

Because these interactions tend to be self-referential and self-reinforcing, the result is often a relatively habitual set of energy behaviours which can be hard to alter. An energy culture will, however, change where there is a change in norms, practices and/or material culture. A change in any one of these is likely to have knock-on effects on the others—for example, the adoption of air conditioning (material culture) changed norms around indoor temperatures in summer (Hitchings & Lee 2008), and aspirations for a more sustainable lifestyle (changed norms) led to a change in energy-related practices (Harries et al. 2013). The energy cultures framework thus helps contextualise household energy behaviour in relation to broad structural influences (e.g. the existence of subsidies; regulations for minimum insulation standards; broad social norms), as well as a way in which a household's norms, material culture and practices shape one another.

The energy cultures framework can also help situate 'efficiency' and 'curtailment' behaviours (Gardner & Stern 2002) within a more dynamic and contextualised setting, seeing these as a continuum of frequent to infrequent practices. 'Practices' in the energy cultures sense is somewhat different to 'practice' in the practice theory sense. In practice theory, practice is seen as a routinised type of behaviour comprising "forms of bodily activities, forms of mental activities, 'things' and their use, background knowledge in the form of understanding, know-how, states of emotion and motivational knowledge" (Reckwitz 2002, p. 249). The energy cultures framework, in contrast, uses the plural form practices and differentiates between practices, things and mental states, while recognising that these are interrelated (Stephenson et al. 2015). Practices in the energy cultures sense include everyday routinised activities as well as actions that may occur relatively infrequently in the life of an actor, such as the acquisition of new appliances. Both occasional and routine actions are equally cultural practices, because across this continuum of frequency, people are enacting and reproducing a way of life that reflects their view of themselves as social actors. The so-called 'efficiency behaviours' (Gardner & Stern 2002) which involve irregular adoption of new technologies can thus be seen as new practices (i.e. the action of choosing and acquiring a new item of material culture) which then result in a change in the material culture of the home, which may then go on to stimulate new or different practices and norms. 'Curtailment behaviours' are new practices in their

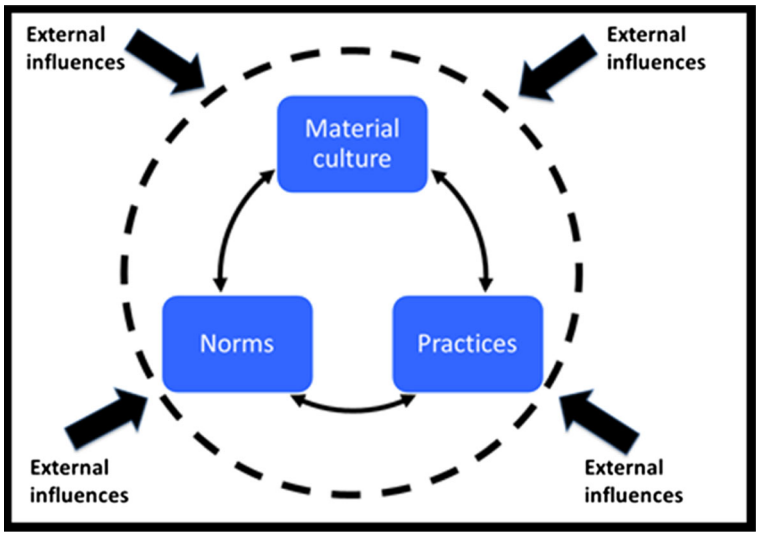

Fig. 1 The energy cultures framework (Stephenson et al. 2010, 2015)

own right, which may then go on to influence the norms or material culture of the household. And, both are shaped by external influences such as the existence of subsidies, the cost of power and (in relation to this research) the provision of home energy audits or community energy events.

The energy cultures framework thus offers an insightful set of perspectives with which to engage with the concept of energy efficiency behaviour and usefully situates behaviour change in a broader social and cultural context. Accordingly, the energy cultures framework was used to underpin the research design, to ensure that the various dimensions of energy behaviour were accounted for in the design of the interventions and also to provide a basis from which to structure the evaluation process.

Method

The study investigated the effectiveness of two different interventions intended to support householders in taking actions to make their homes warmer, drier and more energy efficient. As noted above, one of the interventions was to offer free home energy audits, aimed at improving both basic energy knowledge and to provide advice crafted to their own home and situation. The other intervention involved running three community energy events in conjunction with a well-established community organisation, aimed at improving basic energy knowledge as well as engaging a wide social network in the idea of making their homes warmer and drier. *Our hypothesis was that energy events would provide a more effective platform to encourage participants to successfully carry out energy-related changes in their homes.*

The study evaluated whether the interventions (1) helped to increase peoples' energy awareness or energy literacy, (2) shifted aspirations and expectations relating to domestic energy use and (3) resulted in physical and behavioural changes that would result in greater energy efficiency. In addition, broader and more contextualised conclusions were drawn from interviews.

As the focus of this study was on warmer, drier and more efficient homes rather than a direct reduction in energy consumption, outcome measures such as energy consumed were not considered to be the most appropriate indicator of effectiveness. The audits were not repeated as a follow-up to measure change to the material culture of participants' homes. On a practical level, the cost would have been too high to repeat the audits. The study was designed to explore beyond the individual home and to look at shifts in overall energy culture, including norms and practices.

The research was undertaken in the city of Dunedin, which is in one of the colder regions of New Zealand, towards the south of the South Island. Dunedin has a mean high outdoor temperature of 18.3 °C in summer and a mean low of 3.8 °C during winter (National Institute of Water and Atmospheric Research Ltd NIWA 2013). New Zealand, in general, has a high proportion of older homes with poorer insulation compared to other countries with similar climates (Wilton 2005). The mean indoor temperature in living areas in

this region during winter months is 14.7 °C (Isaacs et al. 2010). The city thus represents the cooler extremity of New Zealand's energy culture (Figs. 2 and 3).

The intervention study took place in three separate parts of the city: two suburbs within the urban part of the city and one settlement in the city's peri-urban fringe. Blueskin Bay, a peri-urban area, 20-min drive from the city centre, encompasses a number of small settlements that cluster around coastal inlets. The housing is a mixture of small older dwellings and newer homes that are a result of gentrification of the area. Blueskin is locally known for its community-based energy initiatives, which have included stimulating the uptake of home insulation, running energy literacy events and facilitating household solar installations. North East Valley (NEV) is a suburb relatively close to the inner city, mainly consisting of older (late 1800 to 1930s) houses. The area has a high proportion of rented properties, many of which are occupied by students who attend the nearby university. There have been some community-based initiatives to support more sustainable living, but less established than Blueskin. Brockville is a suburb at the outer edge of the city. The predominant form of housing is detached social housing built by the state in the 1950s to 1980s; this is gradually being sold off as private housing, but around one third are still rentals. The suburb is high on a hillside and subject to colder weather than most of the rest of the city. Brockville has well-established community networks; the church plays a major role in community events, and several local sustainability initiatives operate alongside a strong social charter.

NEV and Blueskin were selected to receive home energy audits, while Brockville was offered community-based energy events. NEV and Brockville were chosen to get different interventions due to some demographic similarity between the communities. They also both have community sustainability groups.

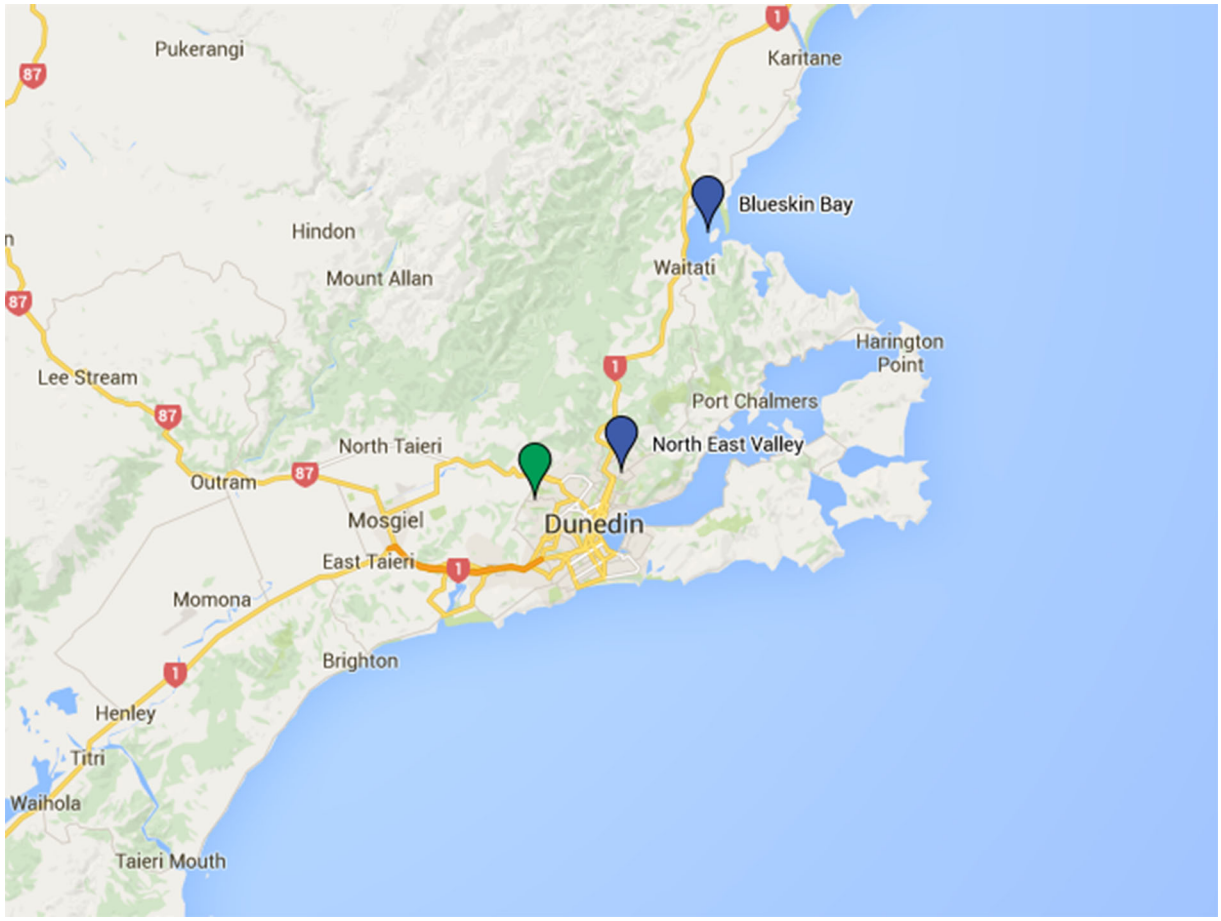

Fig. 2 Map of suburbs in relation to Dunedin and New Zealand (Google maps)

Fig. 3 Map of suburbs in relation to Dunedin and New Zealand (Google maps)

Blueskin was included in order to compare the effect of audits between communities with assumed energy literacy differences. Blueskin already had community energy events; therefore, we planned to compare the outcome of audits in communities pre- and post-community events. Although Blueskin had already run

its own community energy events, they had not previously offered home energy audits. Prior research in Brockville had established a good linkage with a community group, and this relationship was built on, to develop community energy events.

Study process

We sought at least 20 participants in each study area. Recruitment for the audits was via community contacts, local newsletters, community websites, flyers and presentations to community organisations (such as gardening clubs). In Brockville, we worked directly with the Brockville Community Development Project (BCDP), which has direct contact with about a third of the population, established over several years of community engagement. We tried to advertise to the whole community where possible; however, the nature of recruitment in this way means that all participants self-selected, which means that our participants may already have some interest in energy efficiency measures. We did not intend that our results be generalisable and did not attempt to get a representative sample.

The participants in NEV and Blueskin who were interested in the free energy audits were asked to email or call to participate. Once they did, participants were contacted by telephone for further details and were sent a baseline survey (Appendix 1) to fill in prior to receiving their audit. Brockville participants who attended the energy events were invited to fill out the baseline survey at the events and thereby to become study participants.

Follow-up surveys were sent to all participants (Appendix 2). Interviews also were conducted with a subset of participants post-intervention to give a richer picture of what happened as a result of the interventions. Six to eight months after the final audits and events, follow-up interviews were conducted with a subset of seven participants from each suburb. Interviewees were selected at random by assigning each participant a number and using a random number generator.

Interventions

The home energy audit involved an independent consultant going to each participant's home to assess and recommend on four key elements: building insulation, hot water design, solar orientation and occupant behaviours/practices. The auditor assessed the home with the participant present, discussed the efficiency of the home and answered any questions. Approximately 1 week after the assessment, the auditor produced a report for the participant that had specific, tailored recommendations to improve warmth, comfort and energy efficiency, gave an overall star rating of the home and listed the recommendations by difficulty and cost (see Appendix 3 for an example). Occupant behaviours were not a factor in the star rating that the home was given but were used to give recommendations for behaviour change. The entire audit process was free on the condition of completing the surveys and agreeing to the possibility of being contacted for a follow-up interview.

The three energy events in Brockville took place over 3 months. The first event was held in conjunction with a community potluck dinner. There were 61 people in attendance, comprising 31 adults, 24 children, four research team members and two energy advisors. After dinner, the energy advisor (the same person who conducted the home energy audits) presented a slideshow about household energy and led focus groups to discuss individual household energy issues. The second energy event was collaboratively shaped from feedback from the first event and discussions between the community, researchers and consultant. It consisted of practical workshops on how to install plastic glazing over windows, under floor and ceiling insulation, and wrap hot water cylinders. Twenty-two adults, 11 children, three members of the research team and two energy advisors attended this event. The final energy event took part in conjunction with a Brockville spring clean event. This event consisted of community members and others sharing their stories of how they had changed their energy use in home and aspirational stories associated with renewable energy. There were different booths at this event, which attendees were free to move around and share knowledge. The booths consisted of insulation and plastic glazing workstations, a display of the efficiency of different light bulbs, a demonstration of a home-made wind turbine converted from a washing machine and a bicycle that powered a television. Thirty-seven adults, ten children, five members of the research team and two energy advisors attended the event. Throughout the three events, the researchers encouraged attendees to complete the baseline survey in either a paper-based or online form on the computers provided. Due to the design of the community events, it was not possible to sample participants; rather, they chose to attend and fill in the surveys as they wished.

Measures

The baseline and follow-up surveys used the energy cultures framework as a theoretical underpinning and had sections that covered material culture, norms and energy-related practices in the home. Material culture included items such as 'What proportion of your home has underfloor insulation?', norms had items such as 'I don't think very much about ways of saving energy in my home', and practices had items such as 'How often do you close curtains at night?'. These items were selected to be appropriate for the New Zealand context and were scored on a scale of 1 to 5. The surveys also included demographic and energy literacy questions. The follow-up survey differed from the baseline by including questions regarding changes in energy cultures after the intervention (section 6 Appendix 2). The follow-up interviews were semi-structured and consisted of questions regarding motivations for having the audit or attending an event, whether participants had made changes since the audit/event, what changes were made, perceptions of levels of home comfort before and after the changes, whether they influenced any others to do the same and how the process could be improved. Surveys were used to get snapshots of the participants' energy culture before and after interventions, whereas interviews were used to get more in-depth experiences from the participants. Equal weight was given to both the quantitative and qualitative methods, and they were designed to complement rather than inform each other.

We did not measure outcomes such as temperature, humidity or energy consumption changes. These measures are problematic due to New Zealand housing and health issues as discussed earlier. We instead focused on gathering data across norms, practices and material culture to look at overall energy culture shifts.

Participants

Table 1 provides an overview of the participants and the stages of the study.

Survey participants

Seventy-one participants filled in a baseline survey. Of these, 21 were in Blueskin Bay, 24 were in NEV and 26 in Brockville. Note that in Brockville, more than 26 adults attended the energy events, but not all attended all three events. In contrast with the high numbers attending the energy events, there was difficulty in filling out the intended quota of 20 homes for audits in both Blueskin and NEV. Despite the audits being free, take-up was very slow and the research team had to use multiple methods of accessing community members to attain the quota. Forty-one participants completed the follow-up survey, of these, 11 were in Blueskin, 12 in Brockville and 18 in NEV. Due to only 12 participants who attended community energy events in Brockville filling in the follow-up survey, they could not be quantitatively compared pre- and post-intervention. The quantitative pre- and post- comparative results will therefore focus only on the participants who received an audit.

Table 1 Overview of the participants

	Blueskin	NEV	Brockville
Baseline survey	21	24	26
Energy events	0	0	90[a]
Audits	20	20	0
Follow-up survey	11	18	12
Interviews	7	7	7
Housing	Mostly owners	Mostly owners	Mix of tenants and owners
Income	Highest income	Middle income	Lowest income

[a] This number is the total amount of adults in attendance across all three events; some people may have attended more than one event

Interview participants

Post-intervention interviews were conducted with 21 randomly selected households, seven from each of the suburbs. The interview participants consisted of seven males, nine females and five couples.

Results

The "Results" section is structured in the order that the study progressed. Firstly, the characteristics of the participants will be described. This is followed by descriptive statistics from the baseline measures covering the participants' material culture, norms and practices prior to any intervention. An overview of the audit reports is then presented which includes the star rating of the houses which were given along with what was possible

for that house to achieve as a rating. A statistical analysis that compares material culture, norms and practices pre- and post-audit follows the audit reports. Finally, the results from the interviews are reported, first by discussing changes post-intervention and then by focusing on changes in energy culture and barriers to change.

Participant characteristics

The majority of participants, over 95 %, lived in detached houses, with the remainder living in apartments or other situations. A considerably larger proportion of Brockville participants lived in rental homes than those from NEV and Blueskin (Fig. 4). Close to one third of Brockville participants lived in state-owned rental housing.

Figure 5 shows the differences in income across suburbs. Participants from Brockville had the lowest average income, followed by NEV. A similar percentage of both NEV and Blueskin were in the highest income bracket.

Baseline measures

This section discusses the material culture, energy practices and norms of households prior to the intervention, as well as their levels of energy literacy. Table 2 provides an overview of this information.

Material culture

Participants had lived in their homes for 9.05 years (SD = 9.05) on average, and they expected to stay in their current house for 4.39 years (SD = 1.01) on average. Houses had a mean number of 8.27 (SD = 2.94) rooms, which included bedrooms, lounges or living rooms, dining rooms, kitchen areas, studies or offices, bathrooms, toilets and laundry rooms, and 4.34 (SD = 1.65) bedrooms across all suburbs. On a scale of 1 (none) to 5 (all), there was a high level of ceiling insulation ($M = 4.36$, SD = 1.04), but low level of houses with double glazing installed ($M = 1.65$, SD = 1.29) or draughty windows and doors sealed ($M = 2.27$, SD = 1.41). There were no significant differences on these measures between the suburbs.

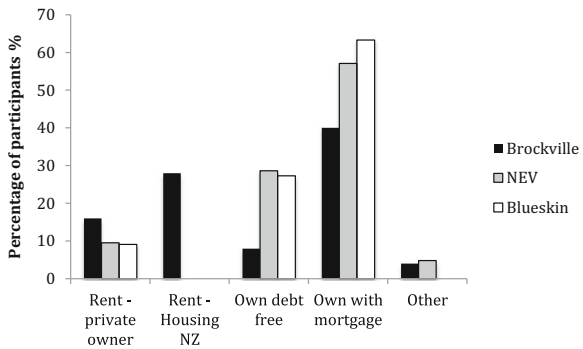

Fig. 4 Housing tenure across the three suburbs

Energy practices

Participants were asked a series of questions in the baseline survey regarding their current energy practices, all scored on a scale from 1 (never) to 5 (always). Across all the suburbs, there were high tendencies to switch lights off in unused rooms ($M = 4.38$, SD = 0.60), close the curtains at night ($M = 4.44$, SD = 0.89), do laundry on cold ($M = 4.34$, SD = 0.99), do full loads of laundry ($M = 4.32$, SD = 0.82) and reduce heating in unoccupied rooms ($M = 4.5$, SD = 0.92). Less common was turning appliances off at the walls ($M = 2.96$, SD = 1.18). Across these practices, there were no significant differences between the suburbs.

There was only a significant difference between the suburbs on one measure of energy practices and that was closing the doors to unused rooms ($F\ (2) = 8.02$, $p < 0.01$). Pairwise tests (Bonferroni) showed that the Blueskin group was significantly more likely to close doors to unused rooms compared to the Brockville group ($p < 0.01$) and the NEV group ($p < 0.01$).

Energy literacy

The baseline survey included questions regarding basic knowledge of energy in the home. Higher scores mean higher knowledge out of a total possible eight correct answers (Section 2 Appendix 1 shows the full set of questions). There was a significant difference between the groups ($F\ (2) = 7.26$, $p < 0.01$). Pairwise tests (Bonferroni) showed that the Brockville ($M = 5.14$, SD = 1.85) group had significantly lower knowledge compared to the Blueskin ($M = 6.38$, SD = 1.36) group ($p < 0.05$) and the NEV ($M = 6.83$, SD = 0.92) group ($p < 0.01$). There was no significant difference between the Blueskin and NEV groups on knowledge scores.

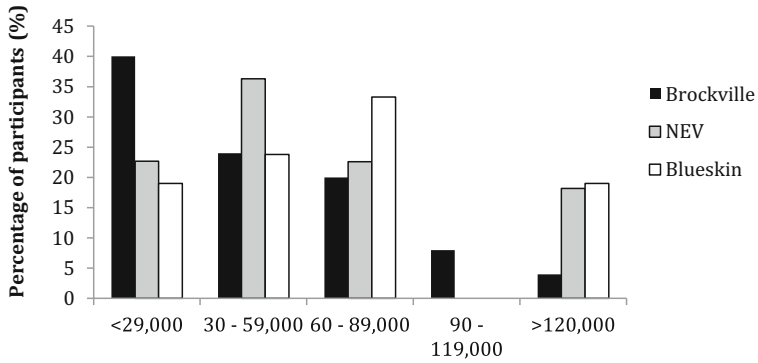

Fig. 5 Household income across the three suburbs

Norms

The survey had a several questions that assessed participants' expectations about their aspirations to change behaviour and the perceived complexity of energy-efficient choices. They scored statements on a scale from 1 (strongly disagree) to 5 (strongly agree). There was a significant difference between the suburbs that making energy-efficient choices around the home is complex (F (2) = 4.03, $p < 0.05$). Pairwise tests (Bonferroni) showed that the Brockville group rated choices as less complex compared to the NEV group ($p < 0.05$). This could be due to the Brockville group having lower overall knowledge compared to the NEV group.

Table 2 An overview of the material culture and practices from the baseline survey

Baseline measures	All suburbs
Material culture	
Time lived in home	9.05 years
Number of rooms	8.27 years
Ceiling insulation	4.36 (max 5)
Double glazing	1.65 (max 5)
Draughty windows/doors sealed	2.27 (max 5)
Energy practices	
Switch lights off	4.38 (max 5)
Close curtains at night	4.44 (max 5)
Cold laundry	4.34 (max 5)
Full loads of laundry	4.32 (max 5)
Reduce heating in unoccupied rooms	4.5 (max 5)
Turn appliances off at wall	2.96 (max 5)

When asked whether they wanted to reduce consumption, use the same amount but more efficiently or increase consumption, there was a significant difference between the suburbs on desire to increase energy consumption (F (2) = 3.13, $p = 0.05$). Pairwise tests (Bonferroni) showed that the Brockville group was significantly more likely to want to increase their consumption compared to the NEV group ($p < 0.05$). For those who wanted to reduce consumption, there were no significant differences between the groups regarding whether they were motivated by money or environment.

There was a significant difference between the suburbs when asked if they would buy efficient appliances even though they may cost more (F (2) = 4.30, $p < 0.05$). Pairwise tests (Bonferroni) showed that the Brockville group was significantly less likely to buy efficient but more expensive appliances compared to the Blueskin group ($p < 0.05$).

Figure 6 shows external enablers for change influencing the energy cultures framework that emerged throughout the study. The main enabler outwith the interventions themselves was the prior community support and knowledge from the Blueskin Resilient Communities Trust. This affected levels of energy literacy and prior material changes to the home as well as efficient practices in the home.

Audit reports

Figure 7 shows the average actual and possible star ratings received by the householders in NEV and Blueskin Bay for their home energy audits. The rating could range from 0 to 5 stars. Only material culture, such as heating or insulation, counts towards the star rating, and behavioural changes do not impact the result.

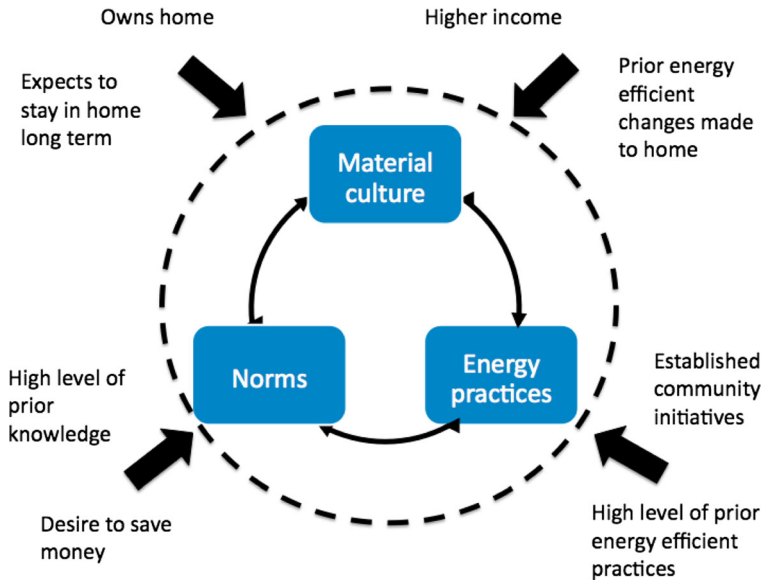

Fig. 6 Major enablers influencing the material culture, energy practices, norms and aspirations of participants

In order to gain the maximum star rating possible, extensive and expensive actions would be required. A 'possible' rating recognises that some houses are physically unable to be improved to reach the highest ranking. Interestingly, the mean possible star ratings are very similar (3.46 and 3.6, respectively) for each community, which indicates that there was not a large difference in household potential. The mean actual star rating is higher for Blueskin (2.2 compared to 1.85); however, this difference is not significant. This slightly higher star rating may be because Blueskin residents had already made the majority of affordable changes prior to the intervention study, a point which will be returned to later.

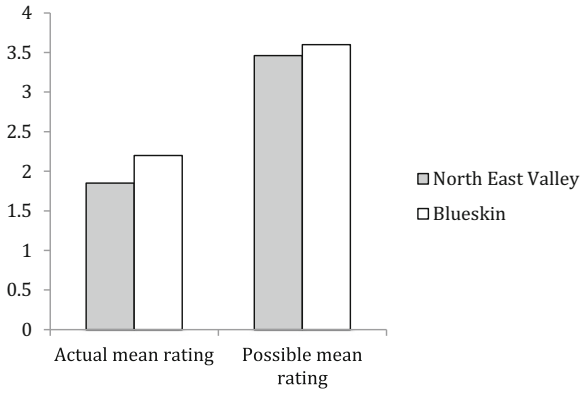

Fig. 7 Actual and possible mean star ratings from the home energy audits

Impacts of interventions

Audit surveys

Due to fewer participants in Brockville completing the survey at the follow-up stage, only the two suburbs that received audits—Blueskin and NEV—were able to be quantitatively compared pre- and post- intervention.

Participants were asked how their energy consumption had changed in the months following the audit. As can be seen in Table 3, most people reported that their energy use had become more efficient.

On a composite measure of material culture that included installed insulation, carpet quality, double glazing and lights, the two suburbs that received the audit did not significantly differ prior to the audit (t (41) = 1.08, p = NS). After the audit, participants overall reported that their material culture had significantly

Table 3 How participants' reported energy use changed in the 6–8 months after receiving an audit, as percentages

How energy use has changed since audit	Percentage (%)
More efficient	38.1
Energy use has not changed	23.8
More frugal	16.7
Make my home more comfortable	16.7
Use as much as I want	2.4

improved compared to before the audit (t (19) = −4.59, $p < 0.01$).

Prior to the audit, the two suburbs did not significantly differ on the measures of energy practices (t (40) = 1.58, p = NS). This measure included behaviours such as drying laundry outside, washing on a cold temperature, turning appliances off at the wall and reducing heating in unoccupied rooms. After the audit, participants reported performing more energy-efficient behaviours compared to before the audit (t (19) = −2.69, $p < 0.05$).

The follow-up interviews revealed some striking differences in energy changes among the three communities following the community energy events and audit interventions.

Audit interviews

All seven interviewees from NEV reported making physical and/or behavioural changes within their homes as a direct result of the audit intervention. While the type and magnitude of these changes varied among individuals, NEV interviewees each attested to making multiple changes within their homes, encompassing both small-scale changes (e.g. pelmet installation, purchasing or creating home-made draft stoppers, curtain replacement) and some large-scale changes (e.g. installing wall or roof insulation, carpet replacement, double-glazing windows). Not all of these changes were captured by the survey, for example, putting a window-insulating film on windows as an alternative to double glazing. Furthermore, NEV participants talked of how these changes made an overwhelmingly positive influence on the warmth and comfort of their homes:

> *The cling film [double glazing alternative] has made a huge difference. A ginormous difference… it really stopped the crying windows. Those windows, at the beginning of winter before I put the cling film up, I was wiping them*. NEV female participant.
>
> *Oh yes, the house is more comfortable now. And also we feel as though we're sort of in control of it. That we now know what needs to be done*. NEV female participant.

Interviewees also commented on financial savings as a direct result of the changes made:

> *From say this time last year our bill is probably about eighty bucks less*. NEV male participant.
>
> *In terms of energy bill, we were paying something like $300 a month… I expect we now have at least $100 of savings per month*. NEV male participant.

In contrast to NEV participants, only one of the seven interviewed Blueskin Bay households reported making any changes following the audit intervention. With the exception of one interviewee, all other participants from Blueskin Bay claimed to be well informed with regard to efficient home heating practices prior to the audit process. Our findings suggest that while both Blueskin Bay and NEV participants scored highly in the energy-related knowledge tests, community-based initiatives such as the Blueskin Resilient Communities Trusts (BRCT) had helped facilitate action around household energy practices in the Blueskin area prior to the intervention. This is reflected in participants in Blueskin having slightly higher ratings in the audit compared to NEV (see Fig. 6). As such, the audit process acted more as a validation of what interviewees had already known and achieved prior to the intervention rather than providing new information or spurring new actions. As one interviewee summarised,

> *It pretty much reinforced what I already knew about the house*. Blueskin female participant.

Community energy event interviews

Five of the seven interviewees from Brockville had made changes within their homes as a direct result of the community events, but these changes were typically either small-scale practical changes (e.g. replacing old light bulbs with energy-efficient light bulbs) or behavioural changes (e.g. not leaving appliances on standby, closing curtains at night), with the exception of one homeowner who insulated their ceiling.

However, despite the lack of large-scale changes, most Brockville interviewees testified to learning a great deal about energy-efficient practices during the community events and viewed the intervention as a valuable tool for initiating community awareness on the subject.

> *Now we are more aware of turning lights off as we leave rooms too. And we make sure the boys do it too*. Brockville couple participants.

It was community based and I'm really big with community. And I also thought it was really good to have some education on something that affects you. Because energy is an expensive thing. Brockville female participant.

Event attendees also mentioned that they had discussed the event with friends in the community afterwards, showing that events can be a useful tool for community engagement and continued motivation.

I caught up with one of my friends yesterday who was at the evening and I said "remember eco-bulbs are 8 times more efficient" and she also thought the event was positive. Brockville female participant.
There were a lot of discussions with friends, one women who I know well was in our group and I explained to her what has worked for us. Brockville couple participants.

Examples from within the community were helpful to event attendees and served as an inspiration for change.

most interesting was actually the testimony that [community member] did, what their family did… it was really good. Brockville female participant.
[community members'] story about using half the amount of firewood after insulating was great. Brockville female participant.

Table 4 shows a synthesis of changes reported from the post-intervention interviews.

Changes in energy culture

Figure 8 shows the various changes that participants made post-intervention within the context of the energy cultures framework.

Material culture changes

As previously mentioned, the majority of practical and material changes following the interventions were achieved by NEV interviewees and, to a lesser extent, Brockville interviewees. While the type of material changes varied considerably from house to house, certain items recurred. Interviewees were primarily concerned with finding practical ways of reducing drafts within the house, maintaining warmth without the aid of expensive heating and finding more energy-efficient appliances. Most of the changes made to alleviate these problems were relatively inexpensive and straightforward but required practical action by the householder:

You can see on these blinds, I've [installed] magnets at the bottom so that they sit close to the windows… Those magnetic strips didn't cost much at all, but they hold it in. Brockville couple participants.
We've made sure that all our light bulbs are energy efficient. Every single one of them. Even the lamp bulbs. Brockville couple participants.

Table 4 Reported post-intervention changes by suburb

Suburb	Details	Changes
Brockville—energy events	Lowest income	5/7 made changes—but small ones
	Most likely to rent	Discussed events afterward within community
	Had lower baseline knowledge	
	Considered energy efficiency choices less complex at baseline	
	More likely to want to increase consumption	
	Less likely to buy more efficient but expensive appliances	
Blueskin—audits—previously had community energy events	Highest income	Only 1/7 said that they made changes—they all knew the information already
	More likely to own	
	Had similar potential to NEV but did less	
	May have done everything affordable already	
NEV—audits—had not previously had community energy events	Middle income	All seven interviewed made changes
		Claimed very positive change in comfort
		Claimed bills lowered

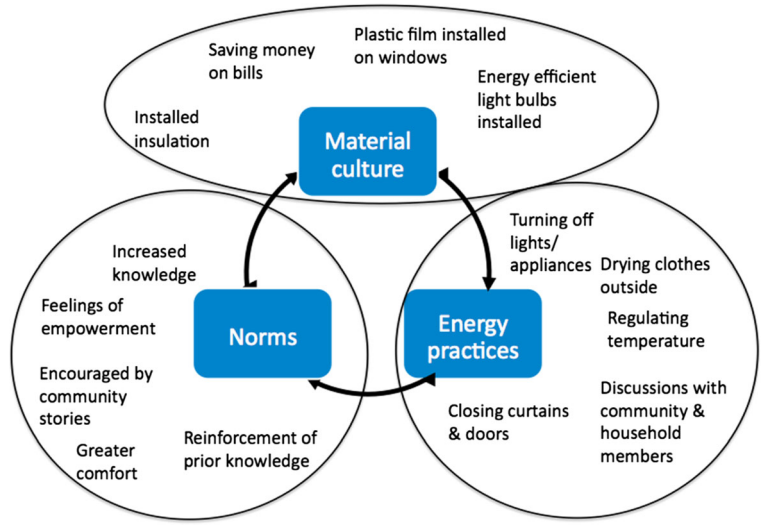

Fig. 8 Changes to material culture, norms and practices as a result of the interventions

In contrast, where more expensive changes were made, people paid professionals to assist:

> *Had them put insulation in the ceiling… It took them less than two hours. And it cost $1200 for the entire ceiling*. NEV male participant.

It is likely that socio-economic and circumstantial differences among the communities play an influencing role in each household's ability to make practical and material changes. We discuss this further below.

Changes in energy practices

The interviews revealed a number of changes in the energy practices of participants following the intervention. The following examples of new energy practices relate to curtailment. Much like our findings of material culture change, changes in energy practices were observed primarily in interviewees from NEV and, in some cases, the other suburbs. A number of participants made changes in energy practices relating to heating:

> *Last year I kept the heat pump at 30 degrees, but now I put it at 24 degrees and it's working better. But now I also clean [the heat pump] myself, so that that helped. That was one recommendation that I followed*. NEV female participant.
> *[the energy advisor] had one really neat suggestion. We always come in through the front door. Because there are no screen doors in New Zealand, when you open it [after] a couple of seconds you lose ten percent of your heat…so he said that in the winter we should come in through the conservatory and enter the house that way because that's almost like an airlock because there is an outer door and through the conservatory there is an inner door*. Blueskin couple participants.

Others adopted new practices relating to energy conservation and reducing condensation:

> *We don't leave anything on at night, we don't leave them on standby. Everything at the mains we switch off… In the past we left all that on. Switching off the appliances, now that is pretty recent. Just after [the intervention] visit really*. NEV female participant.
> *First thing we changed [was to not] dry clothes [in the house]… Because it puts too much moisture in the air. So now we've changed the washing lines and we've got a washing line out the back there. And I've put a cover over it, so that the washing goes out there and doesn't get wet from the rain*. NEV female participant.

Changes in energy practices were less frequently discussed in the interviews compared to material culture changes.

> *I was already doing all that. As soon as I come into my house I close my curtains. When it's cold, this all just stays shut during the day when I'm not here… But like today, I want the light and the sun. But if it was raining and snowing that would be closed*. NEV male participant.

Interestingly, none of the interviewees who had changed their energy practices reported relapsing or reverting back to previous behaviours at the time of interview (6 months following intervention), suggesting that such interventions provide enough incentive to initiate long-term behavioural change.

Changes in norms

Norms comprise how people expect or desire to live. The interventions had an effect on what people aspired to in their homes. As well as the changes they had already made, participants talked about future ideas or plans that they had for their households.

> *I keep an eye out for energy star rated appliances now… I've actually since got a new TV and it has seven star [energy rating].* Brockville male participant.
> *I'm totally in to double glazing now. I mean in England every house is double-glazed. I've been there and the houses aren't as cold… I want warmth now.* NEV male participant.

Barriers to change

Figure 9 shows the external barriers hindering change around the energy cultures framework. The main barriers to change were housing circumstances, money and time.

All 21 interviewees alluded to one or more barriers or constraints preventing further change that would otherwise improve the warmth, comfort and/or energy efficiency of their homes. Financial limitations proved to be the most universal barrier to change, affecting interviewees from all three suburbs, albeit to a different degree. With the exception of one household, Blueskin Bay interviewees reported that they had made all practical changes within their financial means prior to the audit intervention. Their discussion of financial limitations usually related to expensive changes such as solar photovoltaic panels or double glazing.

> *I want to make changes but cost is a big barrier at the moment.* Brockville couple participants.
> *I've also had a quote for double glazing. But it's so expensive. Yeah I mean if I did get an injection of cash I don't know what I'd do first… solar panels or insulation… Probably insulation. If I get a double injection of cash I'd do both.* NEV male participant.

A lack of time to make changes was reported by some participants and was often interlinked with the issue of having limited funds:

> *There was at least one aspect that I couldn't actually do…It's money yeah. That and also getting the time to do it.* NEV female participant.
> *The renovation seems to be taking a while to get off the ground…so because we are renovating, we*

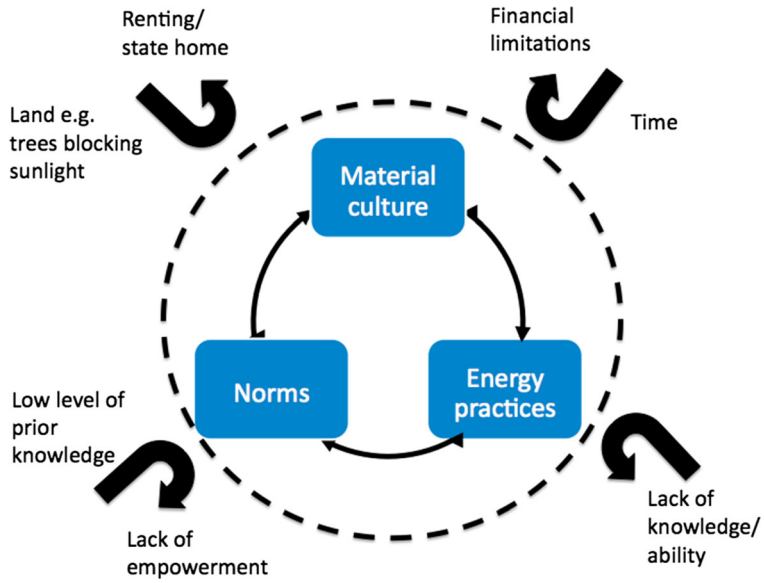

Fig. 9 Major barriers influencing the material culture, energy practices, norms and aspirations of participants

haven't gone ahead with the changes, because we felt it would be more sensible to do everything at the same time. Blueskin female participant.

Perhaps, the most differentiating barrier among communities relates to living circumstances. Interviewees who rented their homes were less likely to make practical changes, particularly any structural change within the house, than interviewees who owned their own houses.

The community benefited from the event more than I did. But that's only because I don't own my own house and I can't make those sorts of changes to a house that I'm renting… My circumstances aren't fitting. Brockville female participant.
The main problem really is the trees. Those trees are never pruned. They need to be cut down a bit. So they keep growing and growing and blocking all of the sunshine. I tried to contact the owners but nothing happened… Out of our control. NEV male participant.

Communication issues

A small subsection of the participants who took part in the energy events felt that the language used was too formal. Knowing the community and having better engagement with the community were recommendations given to improve future energy events.

How do you teach people to engage with communities rather than feeling like you're just being researched? To ensure that you are able to get the information that you need in a way that culturally safe, but also so that people feel that they can participate and contribute… I think by the third event, people were starting to be more upfront with some of their questions and concerns, which is good. And you need to create that kind of atmosphere. Brockville couple participants.

Preference for audit or event

The interviews asked people their preference for energy events or audits. Some interviewees considered that a combination of events followed by audits would be the most practical way of initiating community interest and awareness and then offering the opportunity for individuals to take this further if they wished (subsequent events or a personal home audit).

(Have both) In conjunction I think. It's good to get people talking. So that is probably something that I haven't done enough of as a result of getting the audit. I didn't encourage other people to do it. The event gets people talking. Blueskin male participant.

Discussion and conclusions

Overall, both types of intervention, the personalised household audit and community events, were effective in different ways. The surveys show that the audits had a significant impact on improving material culture and encouraging more energy-efficient behaviours. Findings from the interviews show that audits were most successful at encouraging actual change in NEV. Here, the participants had not previously been subject to much awareness-raising over home energy efficiency actions, and most owned their own homes and were in the medium income range so had the ability to invest in some material changes. NEV participants showed the greatest change in material culture and practices. In Blueskin, where there had previously been a great deal of awareness raising, most audit participants learnt little that was new to them and had done most of what they could afford; essentially, they had already changed their energy cultures as far as they could within their current constraints, although they still aspired for more change. In Brockville, the energy events were most useful in changing norms, for example, developing aspirations to change. Some energy practice changes also resulted, but material culture changes were constrained by the landlord/tenant relationship and cost.

Blueskin Bay interviewees reported far fewer changes after the audit compared to interviewees in NEV. This is likely due to the BRCT initiative in the community that for some years has actively disseminated information and practical advice on energy and energy efficiency changes in households. Blueskin Bay households also scored, on average, slightly higher actual audit star ratings relative to than NEV households. This supports the contention that more Blueskin Bay households had already carried out more small-scale and affordable changes than NEV prior to the audit process. This

finding suggests that home energy audits may not be appropriate in a community that already has high energy literacy and high community engagement in energy efficiency.

Audits may be more successful in communities with a high ability to make changes where they do not already have lots of initiatives/incentives in the community. Energy events may be more useful as an educational platform for building basic energy literacy, encouraging people to aspire to change and enabling people to share their stories of change. There may be value in beginning with community events—to stimulate aspirations and shift community-level energy culture (including energy literacy, encouraging trust in the auditor/s, building from community knowledge) and, following these, conduct the home energy audits (giving specific personalised advice). One issue raised in Brockville was that people would not be comfortable with a stranger (i.e. an auditor) going through their home but that getting to know the person at energy events would make it more likely that an offer of an audit would be accepted. Having an energy event first could also increase general take-up of audits, a problem that the research team did not expect to have during recruitment. Strohm (2011) recommends that highly motivated individuals within the community can encourage others who would be less likely to participate. Utilising a trusted community member as a facilitator for energy events may lead to better engagement and greater uptake of energy efficiency measures.

The energy events did show a shift in norms within the Brockville suburb. Participants reported discussing the events afterward with friends and mentioned how other community members' stories were inspirational. This supports the literature that facilitating informal learning in a social context can support energy awareness (Darby 2006a, b). This shift in norms was accompanied by a shift in practices as seen in the follow-up interviews. Although material culture was more difficult to change within this suburb, their overall energy culture seems to be shifting.

Some participants were unable to make changes due to the fact that they could not alter their rental properties, and this was a particular issue in Brockville where almost half of the participants rented. This constitutes a serious problem due to the poor quality of state housing in New Zealand. As there is no requirement for rental properties to provide either insulation or heating (Howden-Chapman et al. 2012), this lack of empowerment is worrying due to the role that housing plays in health costs (Dunn et al. 2004; Howden-Chapman 2004; Breysse et al. 2004; Toi Te Ora - Public Health Service 2009). In a high-rental community, a more useful intervention could engage with building owners or property managers to encourage energy efficiency measures.

During the community events, it became evident that the delivery of advice and information needs to be tailored to suit the recipient community. As Fuller et al. (2011) state, the characteristics of the target population, trust, language and ease are among other things all important to a program's success. Without adequate knowledge of the social and cultural make-up of a community and a high level of cultural sensitivity, even the best of intentions by an intervening party can fail to promote community engagement and interest. Knowing the community, their community structure, demographics and cultural background prior to engaging in community interventions is essential. While the vast majority of participants were satisfied with the community event proceedings, a small contingent of participants raised some concerns. These included the way that the information was presented, the initial lack of local involvement in developing the style and content and in sharing local stories of change and initiative. Academic-style delivery does not always engage a community audience; therefore, emphasis should be on displays and activities and less on more formal presentations. There should also be a greater emphasis on conversation rather than presentation. Sensitivity to the culture within the community should be paramount as well as being aware of who the target community is for a specific intervention.

This work has tried to give a holistic view of changes resulting from energy interventions. The findings suggest some recommendations for designing such interventions at the community or individual level. Firstly, it is important, even for personalised audits, to know the community that the person is within. If that community already has high knowledge and engagement around energy efficiency, perhaps resources for energy events or audits would be better spent elsewhere. Knowing whether the majority of people are tenants or owners will also help to design better interventions. In a high-rental community, perhaps focusing on landlords or property managers for energy events is appropriate and may

encourage a shift in norms. Audits were a success in a community with little prior energy interventions and a high ability for change, and energy events can be useful to utilise existing social networks. Both interventions were a success when they encouraged change; at the 6-month follow-up, no participants reported reverting back to previous behaviour. This showed that the interventions provided enough motivation to encourage long-term behavioural change. The findings from this work show that greater success is possible with interventions designed to support the situation.

A strong community structure and network has the potential to act as a huge agent of change. Strong community networks often encourage ongoing interest and community-initiated progress check-ups, as the Blueskin example shows. One way of encouraging energy efficiency changes is to support communities to help encourage a shift in norms, practices and material culture.

Audits and energy events were shown to be effective at encouraging a shift in energy cultures in different ways. The three different suburbs had different characteristics, and this work has shown that these two types of intervention can be most effective when targeting the appropriate community. All of the three main aspects of the energy cultures framework: norms, practices and material culture were affected by the interventions. The interventions also had a lasting impact on behaviour change. In some cases, some types of intervention may be more appropriate than others depending on the make-up and history of the community. Therefore, this work gives recommendations as to the type of energy interventions that may be more effective in different communities. Knowledge about the community that is to be targeted for an energy intervention will help to tailor that intervention and ultimately lead to greater effectiveness.

The participants were self-selecting and, therefore, not a representative sample. This means that our findings are not generalisable to the population. It was also very difficult to achieve the target of 20 people to receive audits. There was also some participant drop-off for the follow-up surveys, which meant that quantitative comparisons pre- and post-event were not possible. Careful consideration should go into planning for difficulty recruiting and retaining participants for this type of field work.

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